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Radon Exhalation and Natural Radioactivity Levels of Raw Materials Used Building Industry in Basra Governorate in Iraq

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ABSTRACT

Building materials are one of the potential source of indoor radioactivity because of the naturally occurring radionuclides in them, therefore determined the levels of natural radioactivity and radon exhalation rate from these materials is very important. This work presents measurements, comprehensive and analyses study of natural radioactivity in building materials. For this purpose, 14 types of building material, i.e., brick, cement, gypsum, sand, gravel and brick were, used in building Basra Governorate in Iraq. Radon and its exhalation rate were, measured by using "sealed can technique" using CR-39 nuclear track detector. The activity concentrations radionuclides, 226Ra, 232Th and 40K was measured using gamma spectroscopy with NaI(TI) detector. According to the results of this investigation, brick samples had maximum values of the mean radon contribution concentration and 226Ra concentrations, 279 Bq/m^3 and 9 Bq/kg, respectively. All activity concentrations radionuclides, 226Ra, 232Th and 40K in raw materials (single), are low comparable with UNSCEAR estimation. For group of raw materials included in construction, became high activity concentration.

Keywords: Raw materials, Radon exhalation rate, Radioactivity concentration, CR-39 detector, Gamma ray spectroscopy NaI(TI)

INTRODUCTION

All building materials are mostly composed of rock and soil and these two raw material contain natural radioactivity isotopes such as ^{232}Th and ^{238}U decay series and ^{40}K [1]. Determination of population exposure to radiation from building material is great importance, since people spend about 80% of their life inside the buildings. The activity concentration of natural radionuclides in building material has been estimated in different countries and regions of the world such as Iraq [2-5], Syrian [6], Kuwait [7], Egypt [8-11], Australia [12], Bangladesh [13], Pakistan [14,15], Eastern Europe [16], China [17] and Cyprus [18]. ^{226}Ra is the most important radionuclide in the ^{238}U decay chain from radiobiological viewpoint, therefor, the measurements of ^{226}Ra concentration in building materials considered as reference in all investigations. Natural radionuclides in building materials may cause both external exposure caused by their direct gamma radiation and internal exposure from radon gas [1].

The radiation which people are exposed to my increase if they live in houses or building constructed by using materials whose radiation doses are above normal background level in the area [19].

The concentrations of natural radionuclides in rocks have been found to depend on the local geological conditions and as such they vary from one place to another. Construction materials can, however, cause substantial radiation exposure if they contain elevated levels of naturally occurring radionuclides. Radiation practice comprises the production, trade in or handling of materials with elevated natural radioactivity causing significant excess exposure of workers or public. Natural rocks such as granite, limestone, marble and so on are widely used in building industry; therefore, it is important to measure the concentration of radionuclides in rocks that are used and those that have the potential of being used as building materials in order to assess the radiological risk to human health [20].

In the present work, results of measurements of some important materials (White Cement, White Brick, Limestone, Gray Cement, Sand, Flat Brick, hallow Brick, Coarse Gravels, Middle Gravels) and risk assessment presented in Basrah Governorate. In natural raw materials for cement, concrete, bricks and other building material the activity concentrations of ^{238}U, ^{226}Ra,^{232}Th and ^{40}K varies considerably, depending on both the natural and the origin of the compounds. Generally, natural building materials reflect the geology of their site of origin and average activity concentrations of ^{226}Ra,^{232}Th and ^{40}K in the Earth`s crust are about 40, 40 and 400 Bq/kg, respectively [21,22].

MATERIALS AND METHOD

Samples collection

Fourteen Samples of the most commonly used building materials were collected from manufactures in Iraq, cement, gypsum, brick, and gravel, were gathered from different parts of the Basrah Governorate. Each sample was ground into a fine powder with a particles size <1 mm and dried by heating to 100°C for 24 h to remove moisture.

RADON EXHALATION RATE AND INDOOR INTERNAL EXPOSURE DUE TO RADON INHALATION

The measurement of radon exhalation rate in soil is helpful to study radon health hazard .Radon exhalation rate measurements have been carried out by many workers worldwide using the closed-can a technique. The passive measuring techniques "Can Technique" employing a Solid-State Nuclear Track Detector (SSNTD), a simple and efficient method to assess radon exhalation rates besides being relatively inexpensive, the technique provides quite reliable measurements. The exhalation rate is defined as the rate at which radon escapes from soil into the surrounding air. This may be measured by either per unit area or per unit mass of sample [2]. For our measurement, we designed diffusion chamber for CR-39 SSNTD measurements in hybrid method in the same dimension. These containers were made from polyethylene plastic with dimension 11 cm × 7 cm and the high of sample in the container is 4 cm. The samples were put at the bottom of these vessels. To make sure that all the radon active gas reaches the detector is ^{222}Rn only; a thin piece of sponge has been replaced between the samples and detector. The cans were completely sealed for about 90 days for SSNTDs to allow the radium reach to equilibrium with radon. This step was necessary to ensure that the radon gas is confined within the sample**.** At the end of exposure, the CR-39 detectors were immediately, removed from the cans and etched with 6.25 N NaOH at 70°C for 7 h. The tracks counted for many field areas using 400x microscope to determine the track density per cm^2 [2].The average radon concentration C_{Rn}(Bq.m^{-3}), the radon exhalation rate and the effective Radium content can be calculated by following equations [2,22,23]:

$$C_{Rn} = \frac{\rho}{KT} \tag{1}$$

Where, ρ the track density (Tr.cm^{-2}), K the calibration factor (Tr.cm^{-2}/Bq.m^{-3} d) and T the exposure time (d). The surface exhalation rate of the soil sample for the release of radon:

$$E_A = \frac{\rho \lambda \mathrm{V}}{KA\left[T - \frac{1}{\lambda}\left(1 - e^{-\lambda T}\right)\right]} \tag{2}$$

where E_A are the radon exhalation rate in terms (mBq.m^{-2}h^{-1}), A the area of can (m^2) , V effective volume of the can in m^3, λ decay constant for radon in h^{-1} and T the exposure time in hours, respectively. The effective Radium content C_{Ra} (Bq.kg^{-1}):

$$C_{Ra} = \frac{\rho A h}{KM\left[T - \frac{1}{\lambda}\left(1 - e^{-\lambda T}\right)\right]} \tag{3}$$

where M are the mass of samples (kg) and h are the high of can(m). Radon concentration contributes to indoor radon C_{Rn}(Bq.m^{-3}) is [24]:

$$C_{Rn} = \frac{E_A S_r}{\lambda_V V_r} \tag{4}$$

Where, E_A are the radon exhalation rate, S_r the total surface of room (m^2), V_r the volume of room (m^3) and λv the ventilation rate (h^{-1}). The annual effective inhalation dose for radon AEID (mSv/y), as function for the equilibrium factor for radon F_{Rn} is [25]:

$$AEID = C_{Rn}\left(Bq.m^{-3}\right) * F_{Rn} * 7000\text{ h} * 9\text{nSv}\left(Bq.m^{-3}.h\right)^{-1} \tag{5}$$

RADIOACTIVITY MEASUREMENT AND RADIATION RISK

About 14 various raw materials samples were investigated by using technique of gamma spectrometry NaI(Tl). Gamma spectroscopy with a scintillation detector NaI(TI) (3" × 3"), was used determine the activity concentration of ^{238}U series, ^{232}Th series as well as ^{40}K. The detectors was calibrated using standard sours, ^{57}Co (122keV), ^{60}Co (1173 and 1333 keV) and ^{137}Cs (662 keV), which has 11 radionuclides with 17 resolved energy photo peaks for gamma ray emitters range from 180 to 2614 keV were observed during the measurements. When γ-ray spectrometry was used for the measurement of natural radioactivity in environmental samples, the properly sealed samples must be allowed to remain undisturbed for at least three weeks to attain radioactive secular equilibrium. This is the radioactive equilibrium between ^{222}Rn gas, its progeny (^{214}Pb and ^{214}Bi) and ^{226}Ra, from the ^{238}U decay series. In the ^{232}Th decay series, the radon isotope ^{220}Rn poses no serious problem because of its short half-life of 55 seconds and in the ^{40}K decay series, no equilibrium is needed. For this reason the samples were allowed to stand for three weeks before the spectrum analysis was carried out. The detector is surrounding by a lead shield to reduce the background of the system. In spite of, the background inside lab was measuring and subtract. The progeny was identified according to the energy of gamma line observed. Eight photo peaks were from the uranium series, eight were from thorium series and one was from ^{40}K. ^{226}Ra, ^{238}U, ^{232}Th and ^{40}K activity concentration of relevance to this work are mainly gamma ray emitting nuclei. While ^{40}K can be measured by its own gamma ray, ^{226}Ra, ^{238}U and ^{232}Th radionuclide emit low energy gamma radiation with very low probability and very long life time, Thus, it is not possible to measure ^{226}Ra, ^{226}Ra and ^{232}Th directly by own gamma rays. However, it is possible to measure gamma ray activities of their short lifetime decay products. Therefore, ^{226}Ra, ^{238}U and ^{232}Th activities concentration were determined from their daughter products indirectly under equilibrium conditions [2]. For ^{226}Ra, ^{214}Pb 295 (18.2%) and 351 keV (35.1%) and ^{214}Bi: 609 (44.6%), 1764 (15.1%), 1120 (14.7) and 2204 keV (4.98%) where as for ^{238}U were ^{234m}Pa: 1001 (0.84%) and 766 keV (0.29) where as for ^{232}Th were ^{228}Ac: 911 (25.8%), 986 (15.8%) and 338 keV (11.27%), ^{212}Bi: 727 keV (6.58), ^{212}Pb: 238 (43.3%) and ^{208}Ti: 2614 keV (35.64%) gamma ray. For a simple comparison, the weighted mean values are a good indication; therefor the weighted mean specific activity of the samples was calculated [2]. Activity Concentration of any Gamma-Rays Line A_i(Bq/kg) is [26]:

$$A_i = \frac{C_{net}}{\varepsilon_i \times I_\gamma \times M \times t} \tag{6}$$

Where, C_{net} the peak net count, I_γ the emission probability of specific energy peak, ε_i theabsolute efficiency full energy peak, M the mass of sample, t the time of count period in seconds. The distribution of natural radioactivity in the soil is not uniform. Uniformity with respect to exposure to radiation has been defined in terms of radium equivalent activity Ra_{eq} in Bq/kg to compare the specific activity of materials containing different amount of ^{226}Ra, ^{232}Th and ^{40}K. Radium equivalent activity is related to the external gamma dose and internal dose due to radon and its daughters. The maximum value of radium equivalent activity in building construction materials must be less than the recommended maximum value 370 Bq/kg (OECD, 1979) for safe use and the maximum value of external hazard index H_{ex} allowed is unity corresponding to the upper limit of Ra_{eq} (370 Bq/kg) [18]. The radiation hazard quantities Radium equivalent activity Ra_{eq} (Bq/kg), Absorbed dose rate D (nGy/h) in the air, external hazard index H_{ex}, internal hazard index H_{in}, gamma index I_{Gamma}, alpha index I_{Alpha}, annual effective dose indoor $AEDE_{indoor}$ (mSv/y), annual effective dose outdoor $AEDE_{outdoor}$ (mSv/y) are calculated flowing equations, respectively [27-29].

$$Ra_{eq} = A_{Ra} + 1.43\ A_{Th} + 0.077\ A_K \tag{7}$$

$$D = 0.462 A_{Ra} + 0.6044\ A_{Th} + 0.0417\ A_K \tag{8}$$

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \le 1 \tag{9}$$

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \le 1 \tag{10}$$

$$I_{Gramma} = \frac{A_{Ra}}{300} + \frac{A_{Th}}{200} + \frac{A_K}{3000} \quad (11)$$

$$I_{Alpha} = \frac{A_{Ra}}{200} \quad (12)$$

$$AEDE_{Indoor} = Absorber\ Dose\left(\frac{nGy}{h}\right) * 8760\frac{h}{y} * 0.8 * 0.7\frac{Sv}{Gy} \quad (13)$$

$$AEDE_{Outdoor} = Absorber\ Dose\left(\frac{nGy}{h}\right) * 8760\frac{h}{y} * 0.2 * 0.7\frac{Sv}{Gy} \quad (14)$$

where, A_{Ra} the activity concentration for radium (Bq/kg), A_{Th} the activity concentration for thorium (Bq/kg), A_K the activity concentration for potassium (Bq/kg).

RESULTS AND DISCUSSION

In the current investigation, all types of building materials in Table 1 are used in the construction of houses in Basrah Governorate. Table 1 show the values of radon activity, the radon exhalation area rate, the radium content, the radon concentration contribution to indoor radon and the annual effective dose equivalent and for building materials. It were found that the Brick sample has maximum radon concentration 279.6 ± 73.2 $Bq.m^{-3}$, surface radon exhalation rate 742.2 ± 279.5 $mBq.m^{-2}.h^{-1}$, effective radium 1.9 ± 0.6 Bq/kg. The minimum radon concentrations, surface radon exhalation rate, radium effective are found to be 23.4 ± 6.7 $Bq.m^{-3}$, 62.2 ± 24.5 $mBq.m^{-2}.h^{-1}$, 0.2 ± 0.1 Bq/kg in white brick (Table 1).

It can be seen from the results that the radon concentration varies significantly among building materials as shown Figure 1, this variation may be due to the differences in radium content. The radon exhalation rate varies appreciably from one material to another. This variation may be due to the differences in radium content also [14] and porosity of the soil. It depends on the radioactive content of the materials, emanation factor and diffusion coefficient of radon in that material, porosity and density of the material and permeability of the material are a main factor affecting radon exhalation rate. The radon concentration, in brick is large then another sample this is due to the large radium and uranium contents of sample Table 2. However, only a fraction of radon from radioactive material becomes able to escape to the atmosphere that can be transported to an indoor environment through diffusion and convective flow. The radon concentration, in brick, gravels and san locally much less than Ref [30] and the sand is high radon concentration in spite of the porosity of sand is large [30]. If we imagine, that there are room, built of bricks, cement, gravel fine,

Table 1: The values of the radon concentrations, radon exhalation rates and effective radium contents in the raw material samples

No.	Sample ID	Sample name	Mean radon concentration ($Bq.m^{-3}$)	Areal radon exhalation rate ($mBq.m^{-2}.h^{-1}$)	Radium equivalent content ($Bq.Kg^{-1}$)
1	RBM1	White Cement	27.1 ± 7.7	72.0 ± 28.2	0.2 ± 0.1
2	RBM2	White Bricks	23.4 ± 6.7	62.2 ± 24.5	0.2 ± 0.1
3	RBM3	Cement	32.9 ± 9.2	87.4 ± 33.9	0.2 ± 0.1
4	RBM4	Burke	30.9 ± 8.6	82 ± 31.9	0.2 ± 0.1
5	RBM5	Gypsum	115.4 ± 30.6	306.2 ± 116	0.8 ± 0.3
6	RBM6	Limestone	259.9 ± 68	690.0 ± 259.9	1.8 ± 0.6
7	RBM7	Gray Cement	24.1 ± 6.9	64.0 ± 25.2	0.2 ± 0.1
8	RBM8	Sand	62.1 ± 16.7	164.9 ± 63	0.4 ± 0.1
9	RBM9	Sand	135.7 ± 35.8	360.3 ± 136.3	0.9 ± 0.3
10	RBM10	Flat brick	39.0 ± 10.8	103.6 ± 40	0.3 ± 0.1
11	RBM11	Brick	279.6 ± 73.2	742.2 ± 279.5	1.9 ± 0.6
12	RBM12	Coarse Gravels	192.4 ± 50.5	510.7 ± 192.7	1.3 ± 0.4
13	RBM13	Middle Gravels	275.2 ± 72	730.5 ± 275.1	1.9 ± 0.6
14	RBM14	Fine Gravels	228.3 ± 59.9	606.2 ± 228.5	1.5 ± 0.5
Min.		White Brick	23.4 ± 6.7	62.2 ± 24.5	0.2 ± 0.1
Max.		Brick	279.6 ± 73.2	742.2 ± 279.5	1.9 ± 0.6
Sum			1725.9	4581.9	11.7

Table 2: The activity concentration of ^{226}Ra, ^{232}Th, ^{238}U and ^{40}K in raw materials

No.	Sample ID	Natural of sample	^{226}Ra (Bq/Kg)	^{232}Th (Bq/Kg)	^{40}K (Bq/Kg)
1	RBM1	White Cement	0.7	3.1	11.2
2	RBM2	White Bricks	3.9	3.1	169.3
3	RBM3	Cement	2.3	6.1	14.9
4	RBM4	Burke	5.6	1.6	136.5
5	RBM5	Gypsum	1.8	0.3	131.7
6	RBM6	Limestone	2.9	0.2	446.5
7	RBM7	Gray Cement	4.9	1.1	271.2
8	RBM8	Sand	1.9	0.3	265.3
9	RBM9	Sand	7.7	0.4	136.5
10	RBM10	Flat Bricks	2.7	2.0	106.4
11	RBM11	Brick	9.0	4.2	102.3
12	RBM12	Coarse Gravels	2.3	3.2	179.6
13	RBM13	Middle Gravels	4.9	0.3	175.7
14	RBM14	Fine Gravels	5.1	3.0	183.7

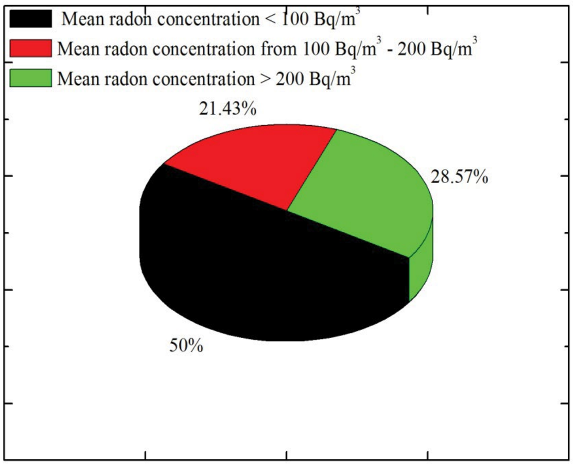

Figure 1: The percentages of radon concentration in building materials

sand, burke and kashi. And, we assume its cavity with S_r/V_r=2.0 m^{-1} and an air exchange rate of 0.5 h^{-1}, the maximum radon concentration, from the building materials, was assessed by the total radon concentration contribution equal to 14.3 Bq/m^3 and the annual effective inhalation dose is 7.3 mSv/y, which area danger when there are no adequate ventilation.

From Figure 1, we noted, 50% of row materials (white cement, white bricks, cement, white cement, gray cement, Sand and Flat bricks) are low radon concentration (less than 100 Bq/m^3) and 28% (gypsum, Butains and coarse gravels) between 100 Bq/m^3 to 200 Bq/m^3. About 28% of raw materials (brick, limestone and fine gravels) great 200 Bq/m^3, which higher than the recommended value in UNSCEAR [31].

Table 2, represents calculated specific activities for ^{226}Ra, ^{232}Th and ^{40}K in row material, respectively. The radioactivity of the investigated raw materials, vary in the 0.7–9 Bq/kg for ^{226}Ra, 0.2–6.1 for ^{232}Th and 11.2–446.5 Bq/kg for ^{40}K. It were found that the brick sample has maximum ^{238}Raactivity 9 Bq/kg, this corresponding with maximum radium content in brick see Table 1. The second maximum ^{226}Raactivity in fine gravels 5.1 Bq/kg, this is corresponding with maximum radium content in fine gravels (Table 1). The minimum ^{238}Raactivityin white cement 0.7 Bq/kg, this is corresponding with minimum radium content in white cement (Table 2).

The values of radioactivity in row materials (single) are low comparable with the worldwide average concentrations of ^{226}Ra, ^{232}Th and^{40}K in soil equal to 32, 45 and 412 Bq/kg, respectively. But, if we imagine, that room are built of bricks, cement, gravel fine, Butain sand, cement, and Flat Bricks, the total radioactivity concentration for ^{226}Ra and ^{40}K are 35 and 947.8 Bq/kg, respectively, which is high than the recommended value in UNSCEAR [31]. The total radioactivity concentration of ^{232}Th is 18.5 Bq/kg, which is less than the recommended value in UNSCEAR [31].

It can be seen from the results that ^{238}Ra, ^{232}Th and ^{40}K varies significantly among building materials, this variation may be due to the geochemical nature and difference in density and particle size of row material. In comparison with other measurement for radioactivity concentrations, in references [5,30,32], in general, we found that our results less than

Table 3: The radiation hazard quantities in building materials samples

Sample ID / Radiation risk quantity	BMR1	BMR2	BMR3	BMR4	BMR5	BMR6	BMR7
Ra_{eq} (Bq/kg)	6.02	21.37	12.26	18.44	12.36	37.46	27.34
H_{ex}	0.02	0.06	0.03	0.05	0.03	0.10	0.07
H_{in}	0.02	0.07	0.04	0.06	0.04	0.11	0.09
I_{gamma}	0.02	0.08	0.04	0.07	0.05	0.16	0.11
I_{alpha}	0.00	0.02	0.01	0.03	0.01	0.01	0.02
D (nGy/h)	2.67	10.73	5.41	9.26	6.50	20.03	14.23
$AEDE_{indoor}$ (mSv/y)	0.01	0.05	0.03	0.05	0.03	0.10	0.07
$AEDE_{outdoor}$ (mSv/y)	0.00	0.01	0.01	0.01	0.01	0.02	0.02

Table 4: The radiation hazard quantities in building materials samples

Sample ID / Radiation risk quantity	BMR8	BMR9	BMR10	BMR11	BMR12	BMR13	BMR14
Ra_{eq} (Bq/kg)	22.78	18.77	13.80	22.92	20.74	18.84	23.58
H_{ex}	0.06	0.05	0.04	0.06	0.06	0.05	0.06
H_{in}	0.07	0.07	0.04	0.09	0.06	0.06	0.08
I_{gamma}	0.10	0.07	0.05	0.09	0.08	0.08	0.09
I_{alpha}	0.01	0.04	0.01	0.05	0.01	0.02	0.03
D (nGy/h)	12.13	9.49	6.92	10.98	10.50	9.76	11.85
$AEDE_{indoor}$ (mSv/y)	0.06	0.05	0.03	0.05	0.05	0.05	0.06
$AEDE_{outdoor}$ (mSv/y)	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 5: A comparison between radioactivity content of building materials in used in Basrah governorate/Iraq and other parts of the world

Sample	Ra-226 Bq/Kg	Th-232 Bq/kg	K-40 Bq/kg	Rn-222 Bq/Kg	Exhalation Rat $Bq.m^{-2}.h^{-1}$	Country/Ref
Brick	9	4.2	102.3	279.6	0.742	Iraq(this study)
	------	------	------	166.55	1.01	Iraq [4]
	37	12.2	851	---------	----------	Iran [1]
	12	7	332	-------	--------	Iran [1]
	195.03	26.14	377.4	2101	1.581	Iraq [30]
	12.5	--------	--------	--------	0.00549	India [35]
	--------	--------	--------	175.9	1.183	Malaysia [36]
White Cement	0.7	3.1	11.2	27.1	0.072	Iraq (this study)
	------	-------	-------	156.7	0.94	Iraq [4]
	49.5	16.7	32.6	--------	--------	Iraq [5]
	-------	--------	--------	--------	0.0794	Malaysia [36]
Gypsum	1.8	0.3	131.7	115.4	0.306	Iraq (this study)
	8.1	2.2	116	--------	------------	Iran [1]
	33.28	47.2	88	--------	-----------	Saudi Arabbia [32]
Limo stone	2.9	0.2	446.5	259.9	0.69	Iraq (this study)
	28.6	49.2	66	-------	---------	Saudia Arabia [32]
Cement	0.7	3.1	11.2	24.1	0.064	Iraq (this study)
	39.6	28.9	290.8	-------	---------	Iran [1]
	--------	--------	------	205.05	1.24	Iraq [4]
	25.6	---------	--------	--------	0.00329	India [35]
Sand	1.9	0.3	265	62.1	0.164	Iraq (this study)
	12.3	24.2	195	------	-------	Saudi Arabia [32]
Flat Brick	2.7	2	106.4	39	0.103	Iraq (this study)
	-------	--------	--------	121.9	0.72	Iraq [4]
Gravels	2.3	3.2	179.6	192.4	0.510	Iraq (this study)
	20.4	6.3	450.7	-------	---------	Iran [1]
	14.7	24.2	195	-------	-----------	Saudi Arabia [32]

its. This difference in the presence of the two series in the sample of quarries is due to the distribution of radionuclide in row materials which is not the same (random distribution), varying in intensity radiation and quantity of radionuclide. This distribution related to the geochemical nature row materials. Generally, the magnitude and distribution of natural-gamma-ray activity related to lithology. Variation of background concentrations of radionuclides in samples depends on the type, moisture content, in homogeneity of its permeability, formation, transport processes and geomorphology associated with meteorological conditions. Soil formation and chemical and biochemical interactions also influence the distribution patterns of ^{238}U, ^{232}Th and their decay products [33].

The distribution of natural radioactivity in the soil is not uniform. Uniformity with respect to exposure to radiation has been defined in terms of radium equivalent activity Ra_{eq} in Bq/kg to compare the specific activity of materials containing different amount of ^{226}Ra, ^{232}Th and ^{40}K. Radium equivalent activity related to the external gamma dose and internal dose due to radon and its daughters. Tables 3 and 4 presented the radiation quantities obtained from ^{226}Ra, ^{232}Th and ^{40}K activity concentration in row materials. The maximum value of radium equivalent activity, in building construction materials must be, less than the recommended maximum value 370 Bq/kg (OECD, 1979) for safe use and the maximum value of external hazard index H_{ex} allowed is unity corresponding to the upper limit of Ra_{eq} (370 Bq/kg), D=60 nGy/h and $AEDE_{indoor}$=0.41 mSv/y world median values respectively [34]. The most of radiation risk quantities for all samples of raw materials are lower than the world median values [31] (Tables 3 and 4).

Table 5 shows the average concentrations of natural radionuclides in the building materials of the present work in the comparison with the results of investigation in different countries [35,36].

CONCLUSION

Due to the presence of radon and radioactive elements in raw building materials, preferably concern by a factor of ventilation when designing buildings, otherwise there will be dangerous when ventilation is poor. The baste raw materials in building industry in Basra Governorate is thermistor instead bricks because low radon concentration and radioactivity concentrate.

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